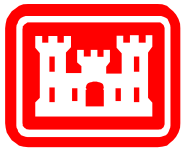
MOUT FACT Project Implementation Meeting
May 14-15, 2003
Monterey, CA

Title: Enhancement of the Mobility Suite to Predict Vehicle Performance Over Roads Degraded by Urban Debris and Craters

John G. Green & George L. Mason

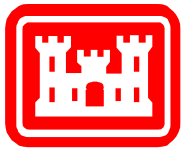


US Army Corps of Engineers

Engineer Research and Development Center

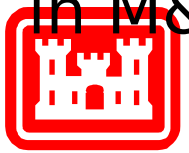
Objective

- Improve the suite of NRMM-based APIs with respect to vehicle mobility in MOUT by developing a methodology to quantify urban rubble and debris and applicable discrete obstacles as defined in the OOS EDM.



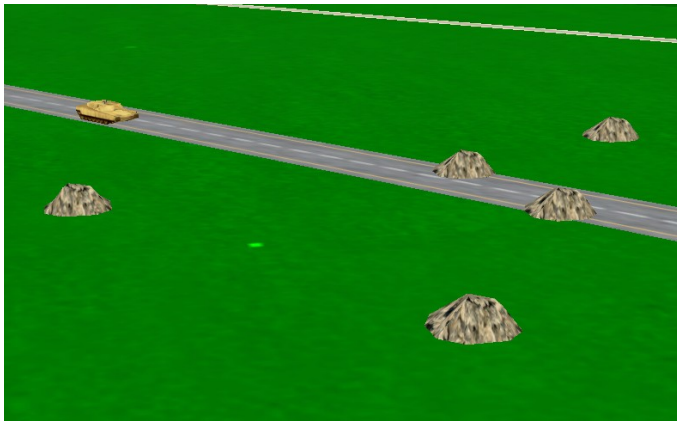
Approach

- Identify current Urban Obstacles (rubble/debris, craters, etc.) in M&S
- Obtain/generate testing data and information
- Obtain vehicle response results (VEHDYN III and field tests)
- Quantify/group results and establish patterns
- Develop urban mobility prediction methods for use in M&S



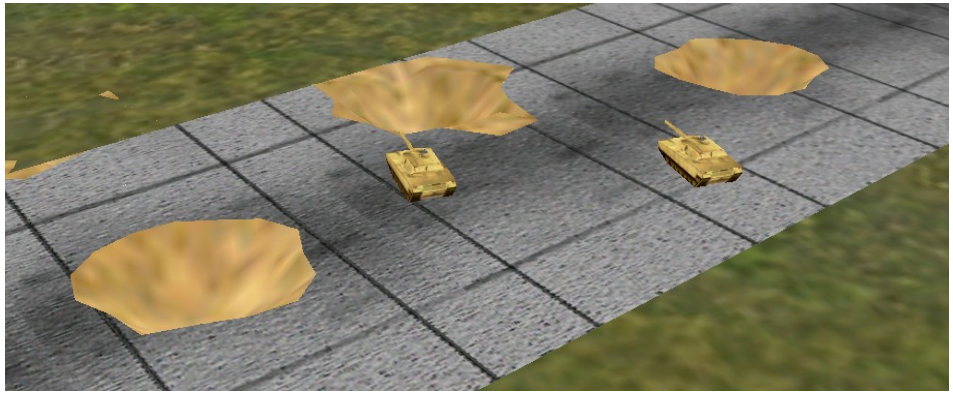
Urban Obstacles in the SAF Environment

Rock Drops



Dragons Teeth

Craters



OOS EDM Terrain Features Considered Obstacles

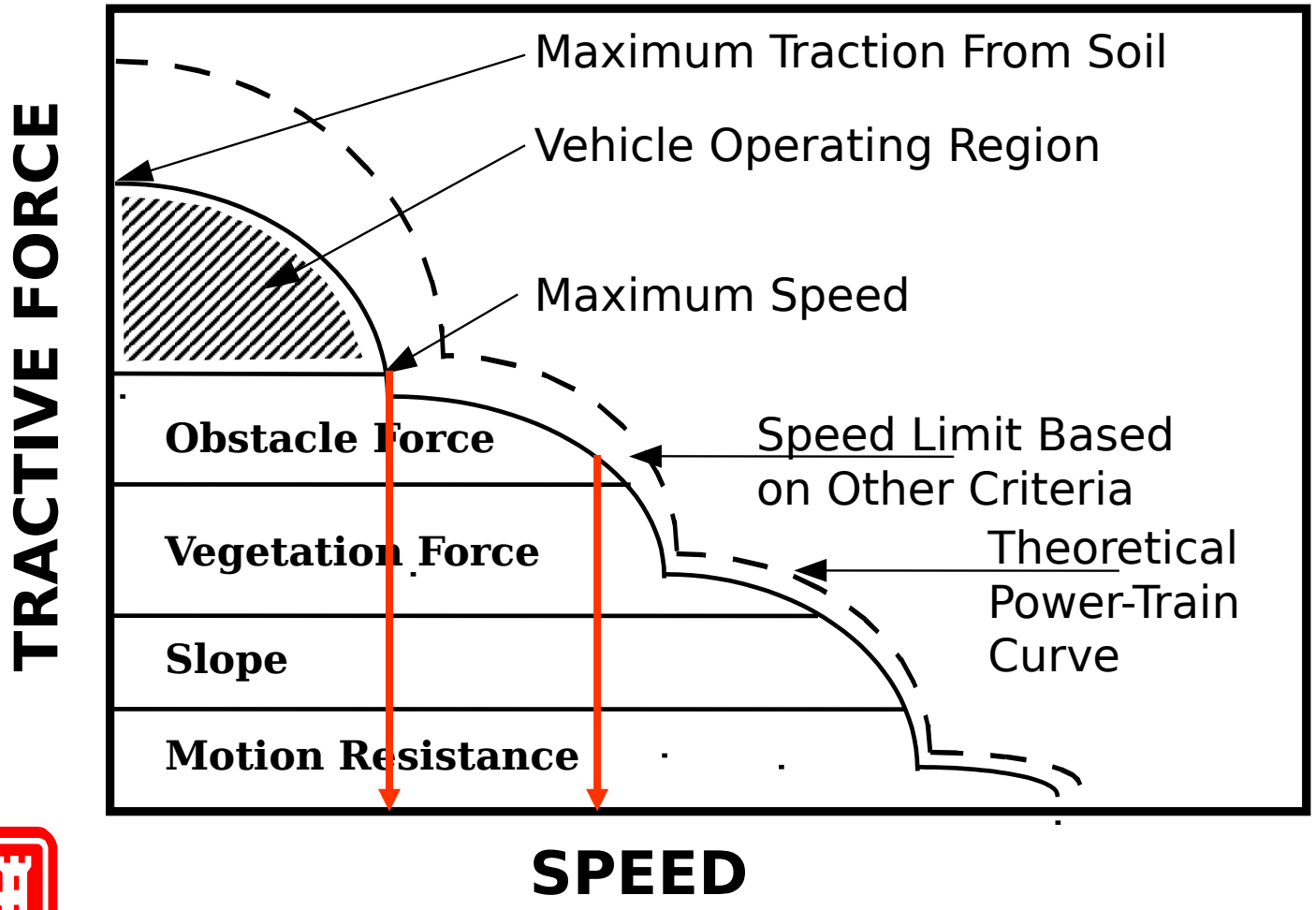
- ABATIS
- BARRIER
- CROSS_COUNTRY_ BARRIER
- DITCH
- DITCH_AND_OR _BERM_ENGINEERED
- DRAGON_TEETH
- EMBANKMENT_OR_FIL L
- MINEFIELD
- MOAT
- RIVER_OR_STREAM
- **ROCK_DROP**
- **RUBBLE**
- **SIDEWALK**
- **TERRAIN_CRATER**
- **TERRAIN_SURFACE**
- WADI_OR_WASH_OR _ARROYO
- WALL

Approach for computing obstacle crossing speed

NRMM II is the Army standard for determining vehicle mobility performance, and its primary output is a prediction of maximum vehicle capable speeds. Simplified, the prediction procedure for determining the speed during an obstacle crossing can be outlined as follows:

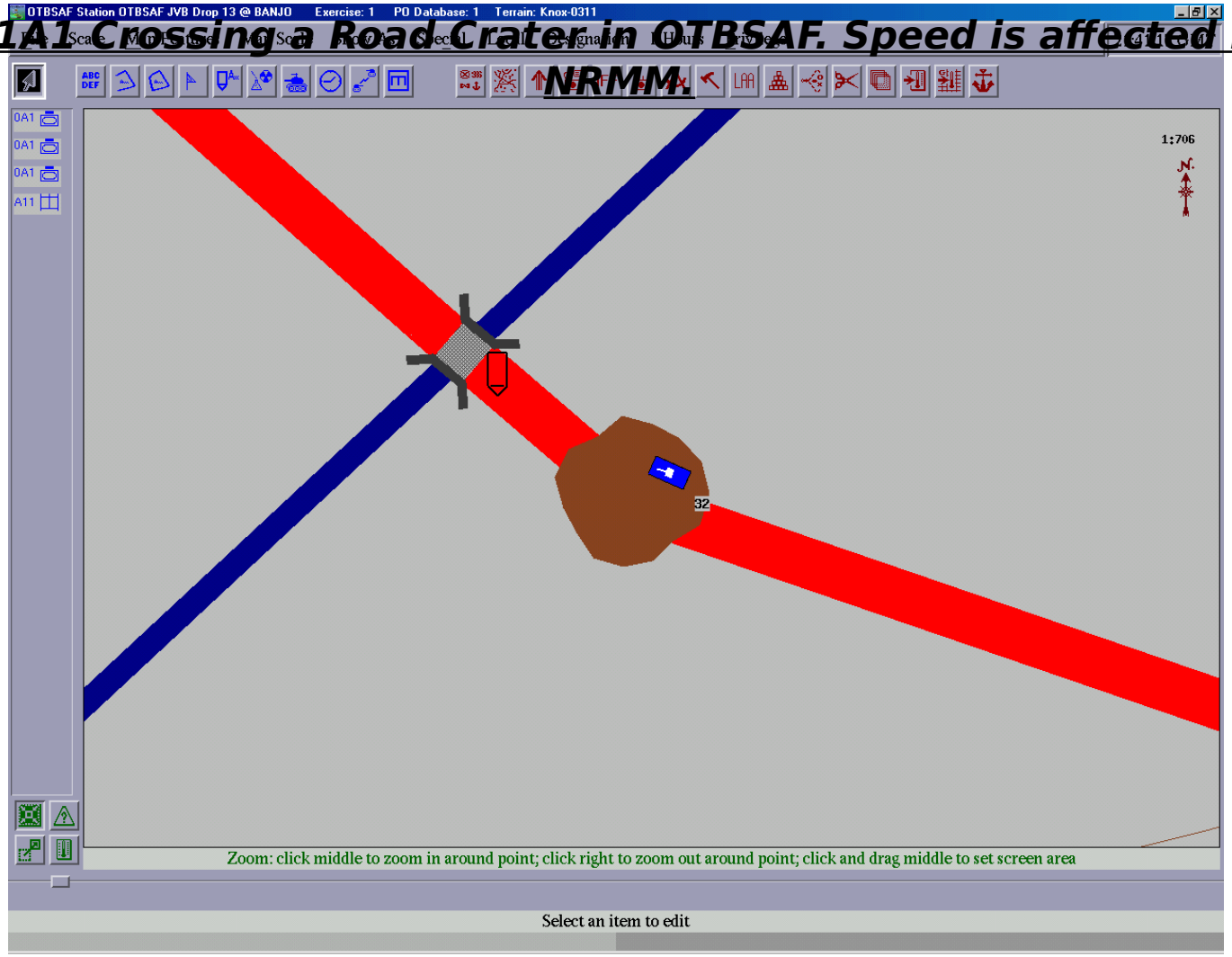
1. Develop a tractive-force speed curve given vehicle characteristics and terrain type and strength.
2. Determine the total of the various resistances to motion (slope, vegetation, obstacle, sinkage, …).
3. Look up or calculate speed.
4. Limit speed based on other environmental conditions (visibility, braking ability, surface roughness, …).

Notional Tractive-Force Speed Curve



Experiences in Urban Obstacle Representation

M1A1 Crossing a Road Crater in OTBSAF. Speed is affected by NRMM.

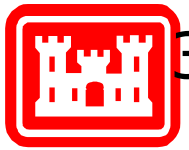

OTBSAF Station OTBSAF JVB Drop 13 @ BANJO Exercise: 1 PO Database: 1 Terrain: Knox-0311
1;706
Zoom: click middle to zoom in around point; click right to zoom out around point; click and drag middle to set screen area
Select an item to edit

US Army Corps of Engineers

Engineer Research and Development Center

Resistance due to an Obstacle

- Data tables of average and maximum resistance forces and clearance based on standard obstacle descriptions.
- Data for these tables are produced using OBSMOD – a 2-D Simplified Force Balance Model.
- The tables are interpolated and the average and maximum resistance forces are used to:
  1. Determine if interference exists. (Go/NoGo)
  2. Determine if sufficient traction is available to cross the obstacle.
  3. Use average resistance to get predicted speed.

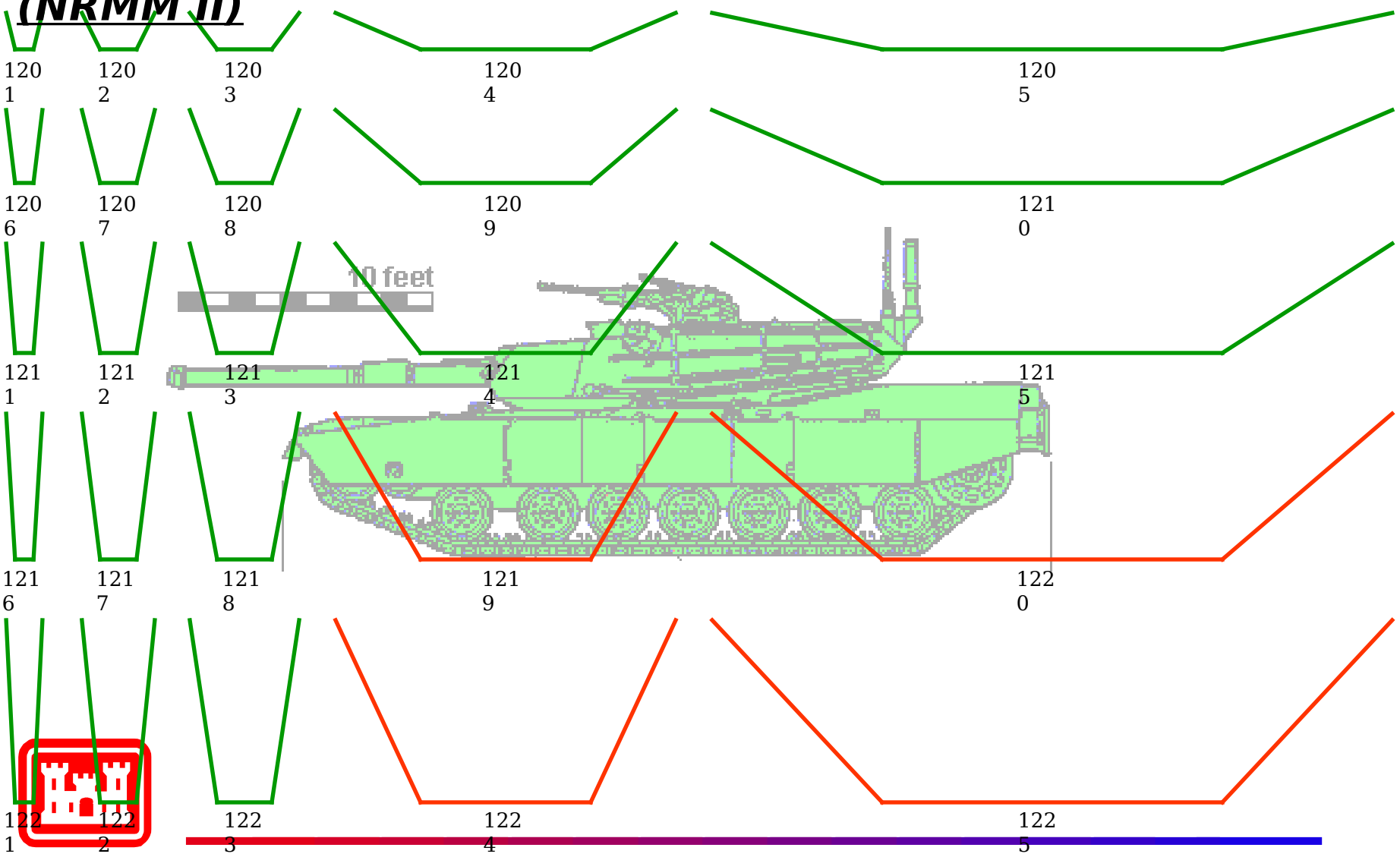


M1A1 Obstacle Crossing Effectiveness on Various Obstacle Geometries (NRMM II)

= GO

= NOGO

0 36 inches

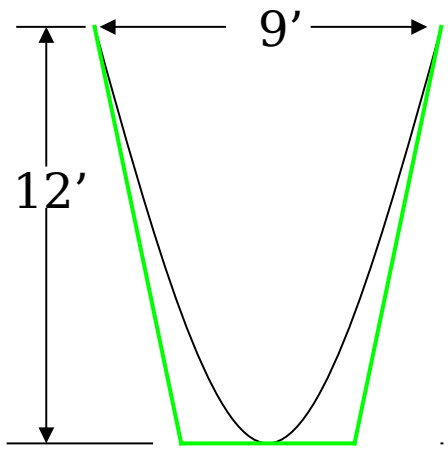


US Army Corps of Engineers

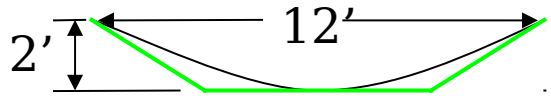
Engineer Research and Development Center

Craters – 2-D vehicle crossing representation for SAF

- Craters are assumed to be of a parabolic form (black).
- Convert crater to NRMM II-type obstacle (green)
- Using slope = atan(4*depth/diameter).



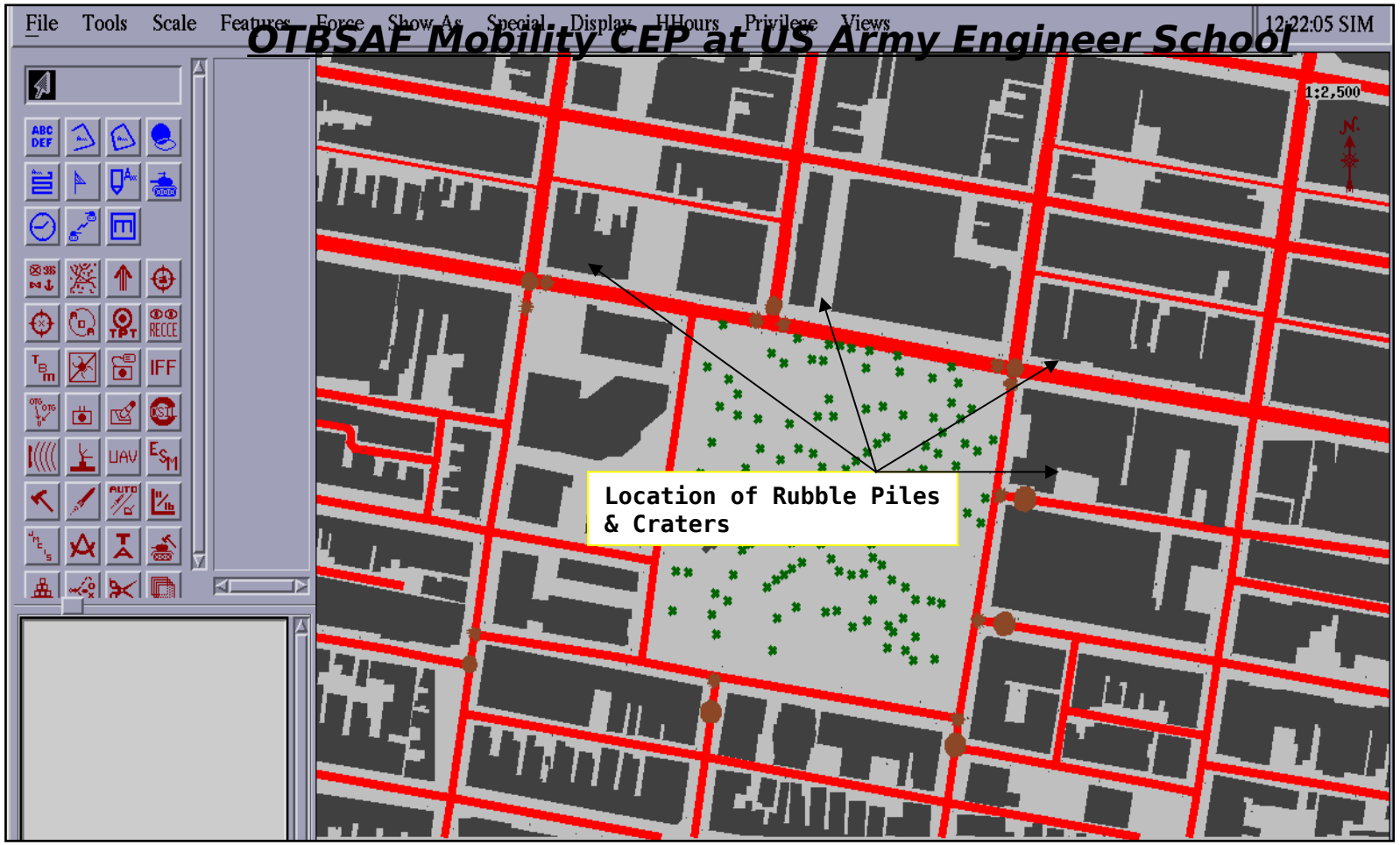
Slope = atan(4*12/9) = 5.33 or 79º



Slope = atan(4*2/12) = 0.67 or 34º

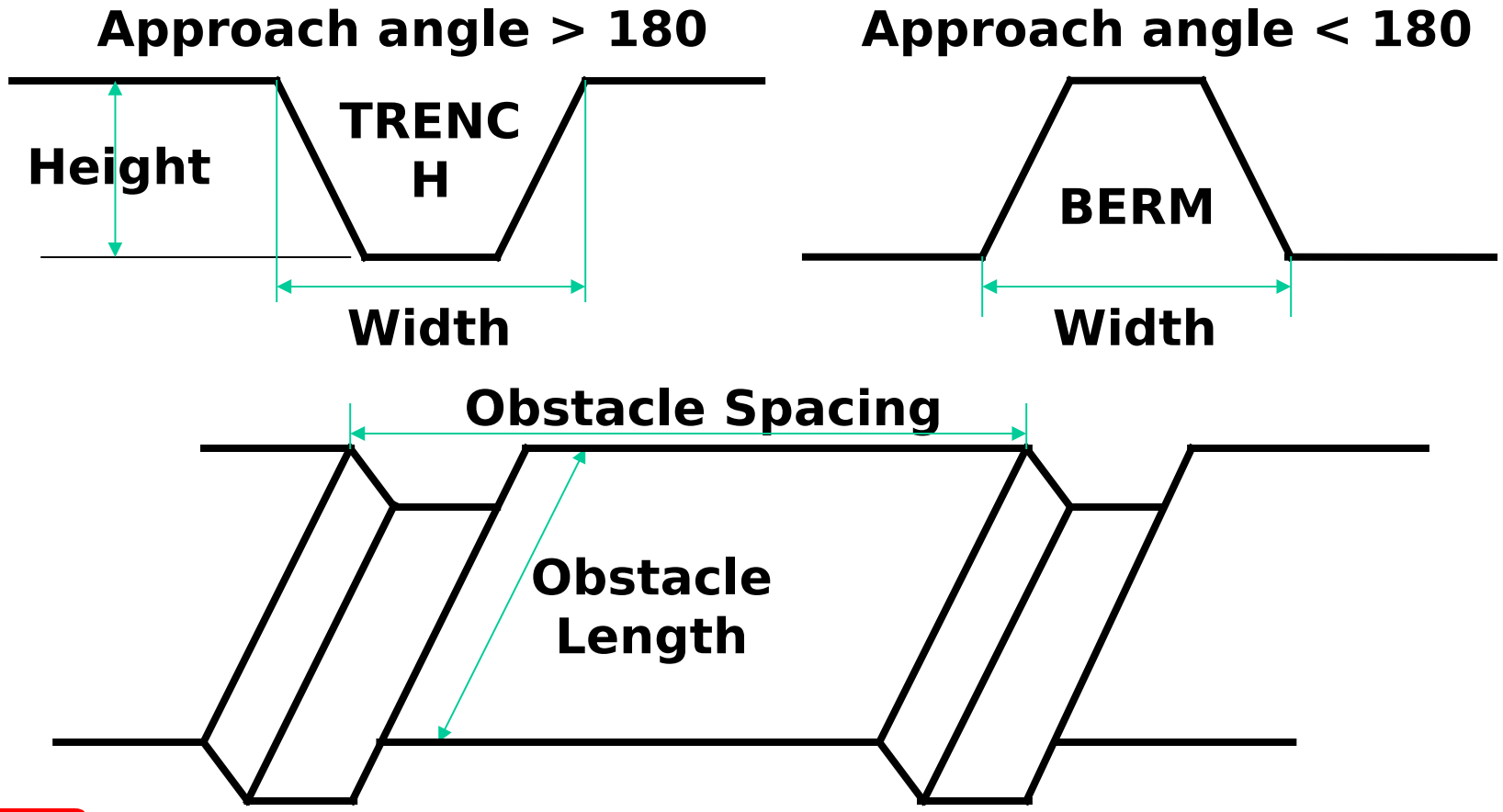
Experiences in Urban Obstacle Representation

OTBSAF Mobility CEP at US Army Engineer School



Experiences in Urban Obstacle Representation

NRMM II Standard Obstacles



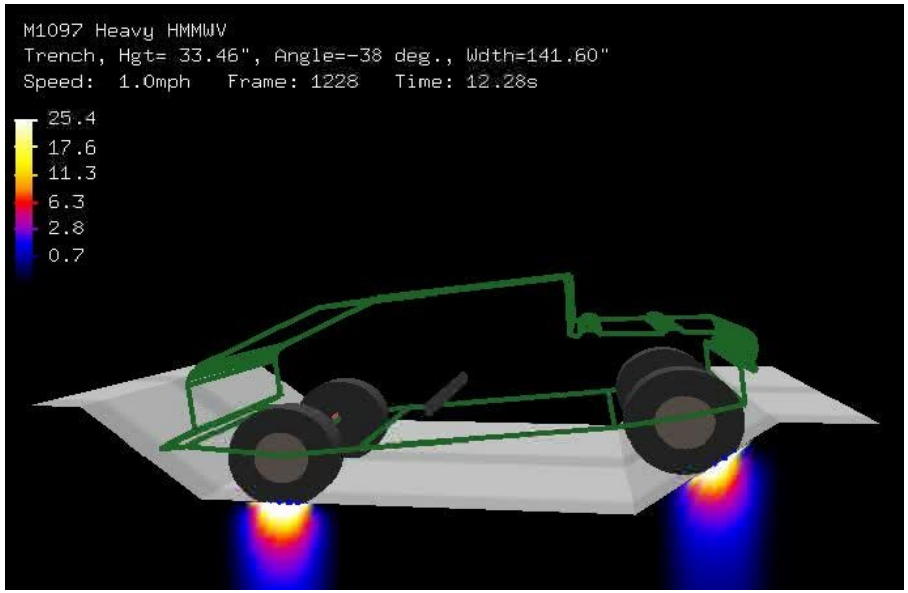
Diagrams of obstacle measurements

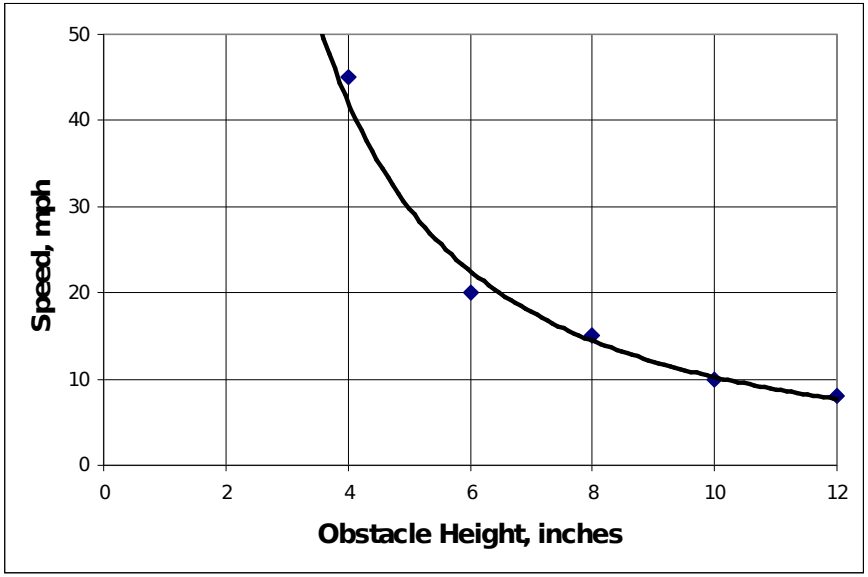
US Army Corps of Engineers

Engineer Research and Development Center

Speed Limit Due to Vertical Acceleration

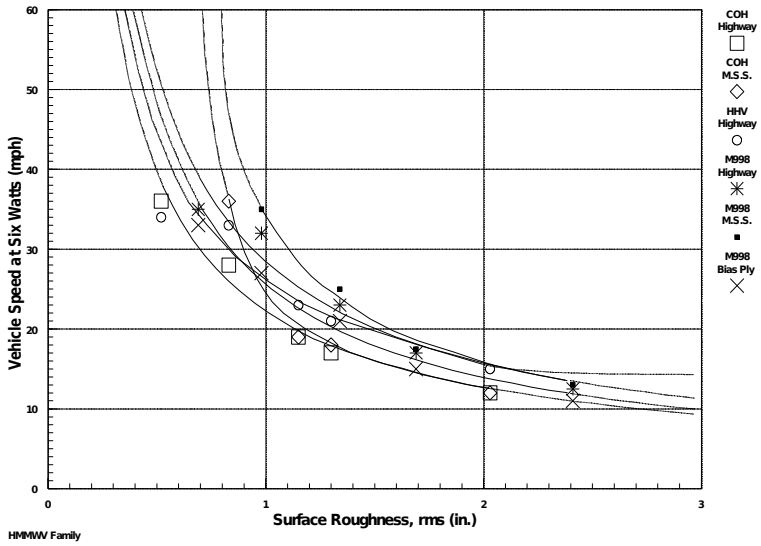
Vehicle speed versus obstacle height is used to limit speed based on vehicle & driver vertical acceleration tolerance (2.5g) via Vehicle Dynamics Model (VEHDYN II)



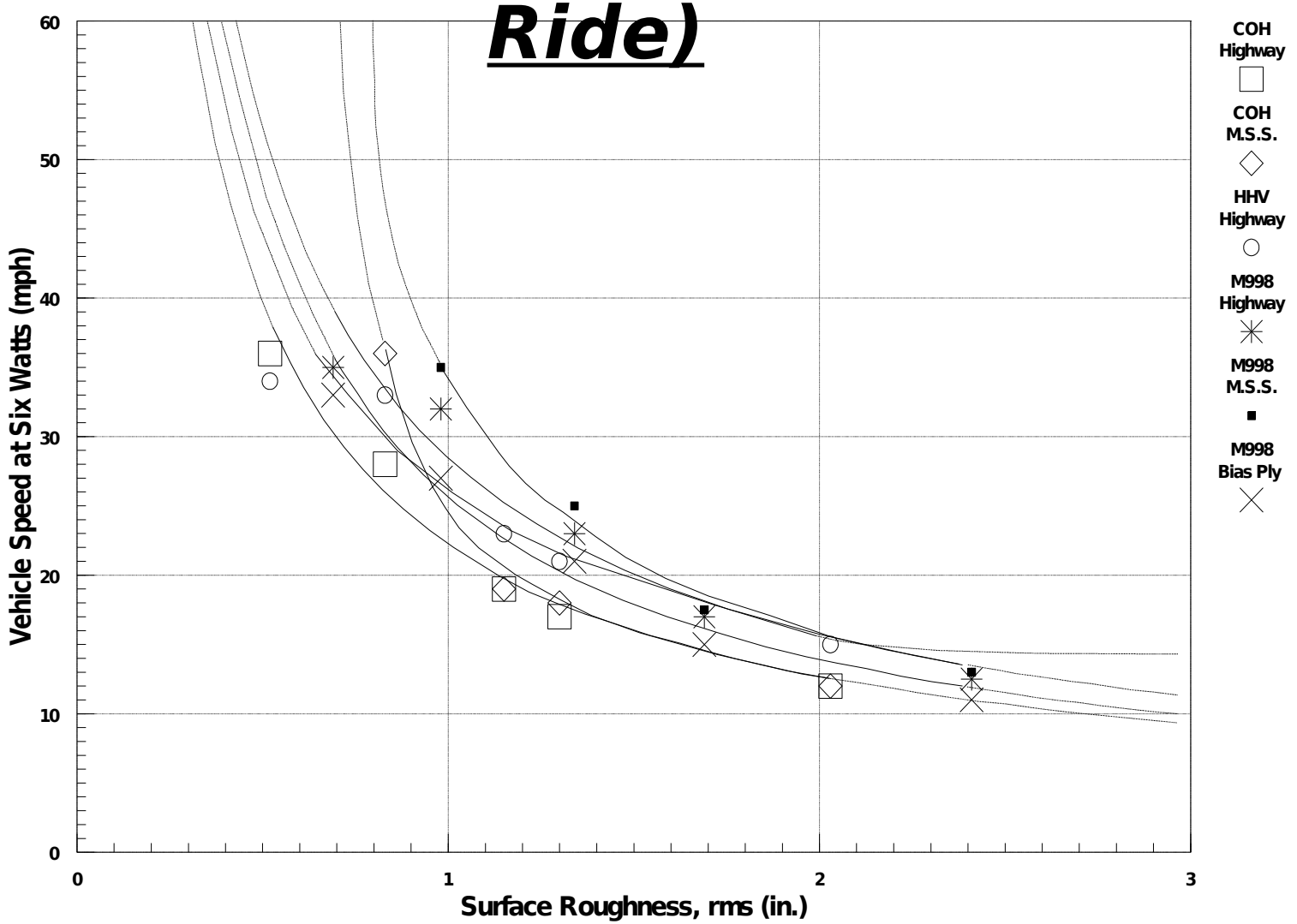


Ride/Shock/Dynamics Testing

- Test Conduct
  - Selection of courses
  - Test site characterization
  - Vehicle instrumentation
  - Vehicle configuration
  - Test technique
  - Data collection/analysis



6 Watts Speed Curves (Vehicle Ride)



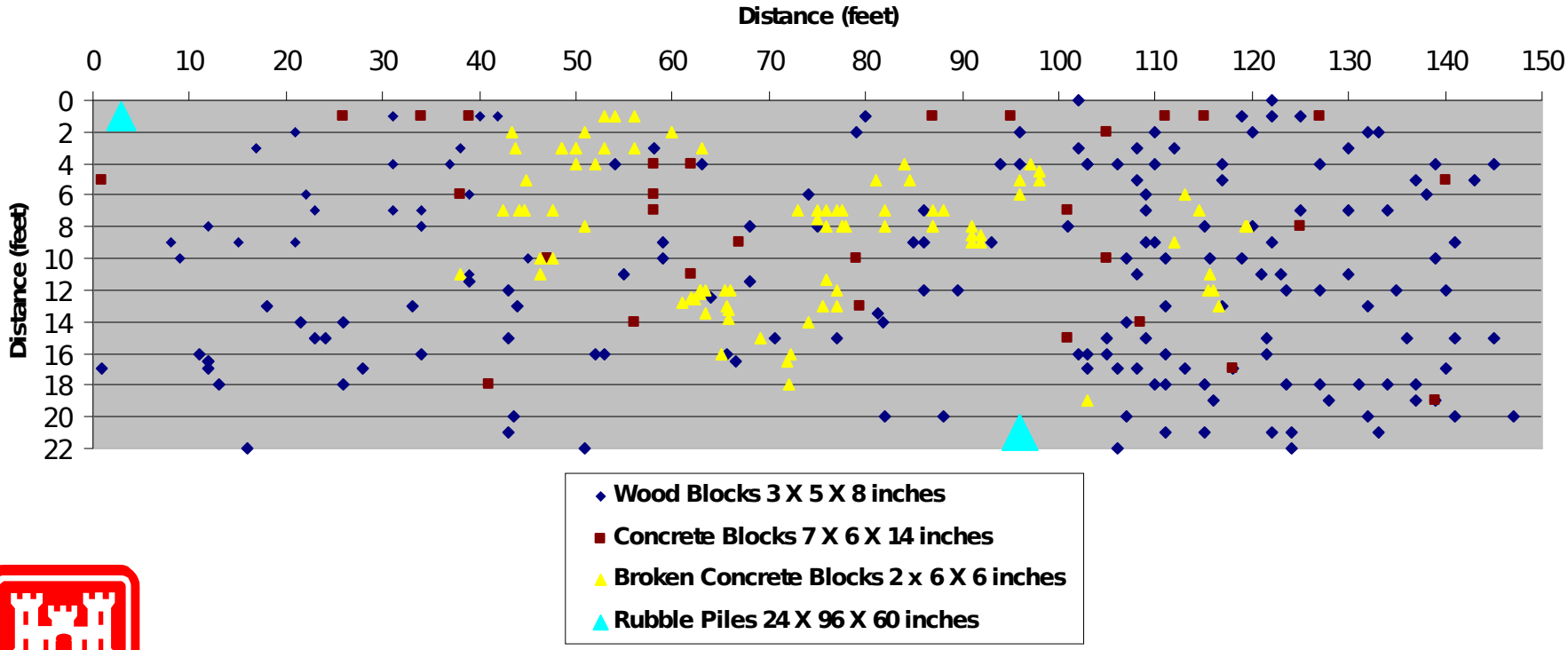
HMMWV Family

HMMWV and ATV over simulated rubble and debris at WES Test Site

US Army Corps
of Engineers

Engineer Research and Development
Center

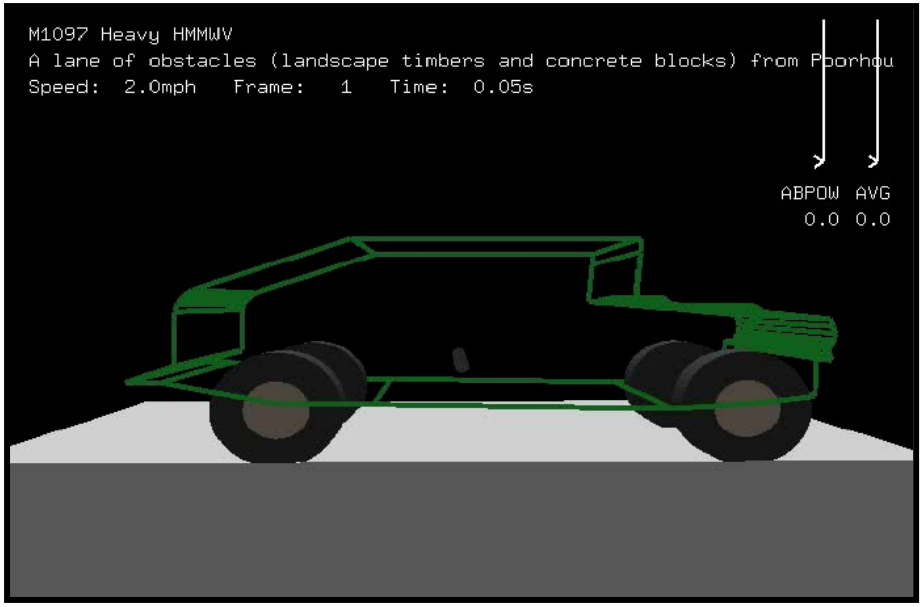
Rubble/Debris Course at WES

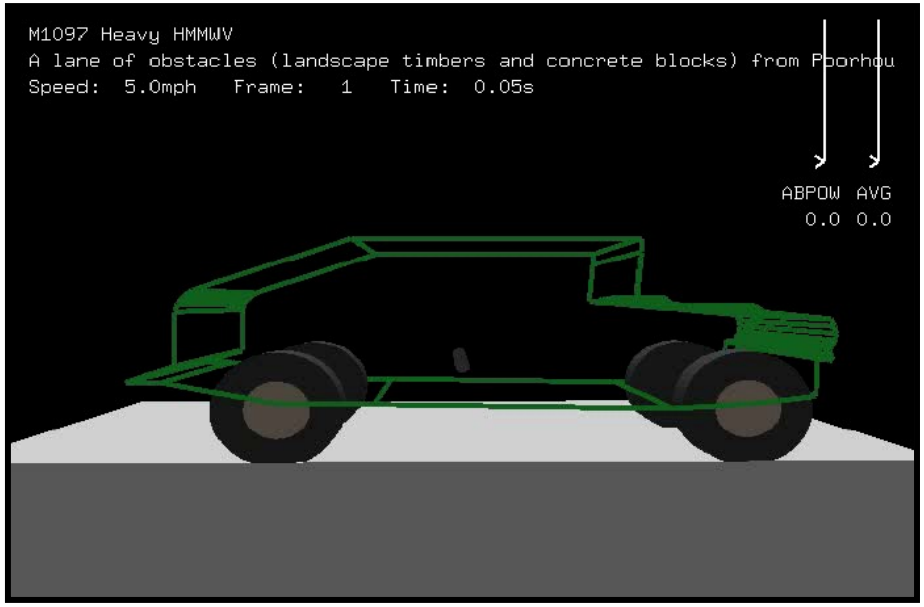

Distance (feet)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
Distance (feet)
0 2 4 6 8 10 12 14 16 18 20 22
Wood Blocks 3 X 5 X 8 inches
Concrete Blocks 7 X 6 X 14 inches
Broken Concrete Blocks 2 x 6 X 6 inches
Rubble Piles 24 X 96 X 60 inches

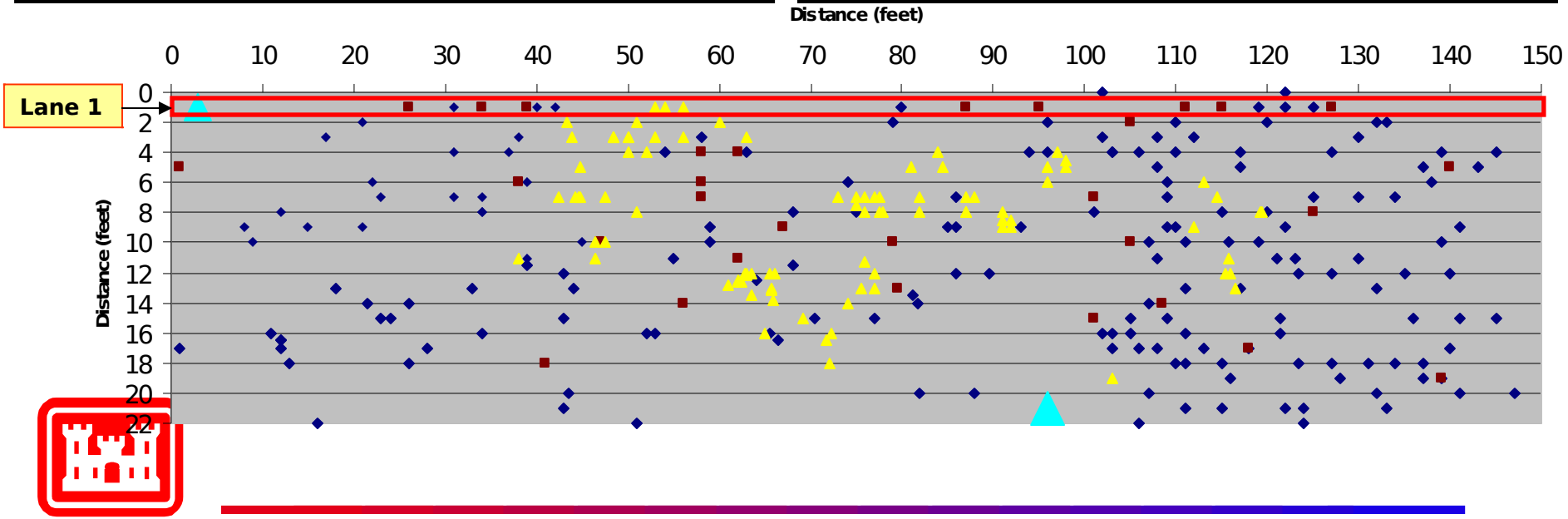
US Army Corps of Engineers

Engineer Research and Development Center

VEHDYN III Over Rubble and Debris (LANE 1)


M1097 Heavy HMMWV
A lane of obstacles (landscape timbers and concrete blocks) from Poorhou
Speed: 2.0mph Frame: 1 Time: 0.05s
ABPOW AVG
0.0 0.0

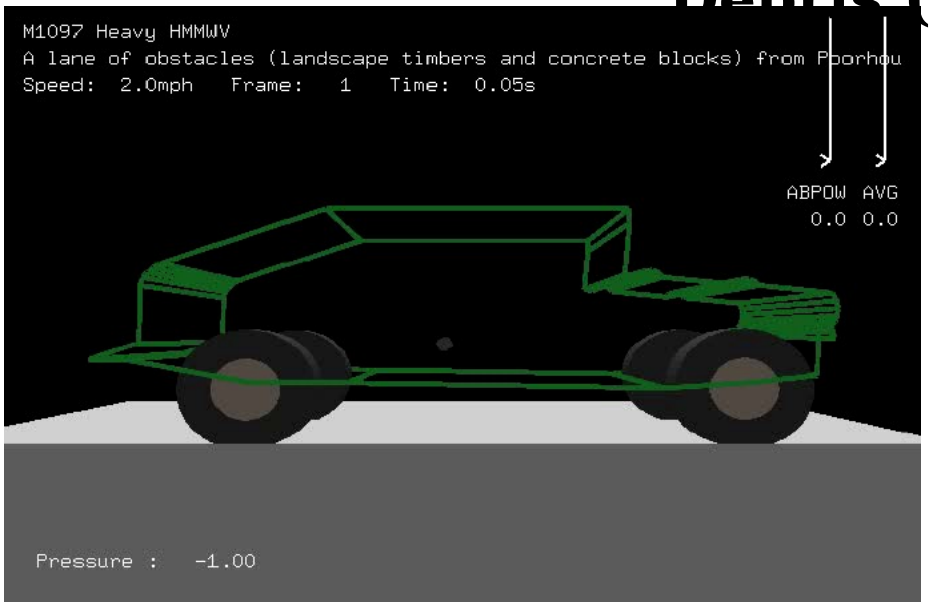

M1097 Heavy HMMWV
A lane of obstacles (landscape timbers and concrete blocks) from Poorhou
Speed: 5.0mph Frame: 1 Time: 0.05s
ABPOW AVG
0.0 0.0

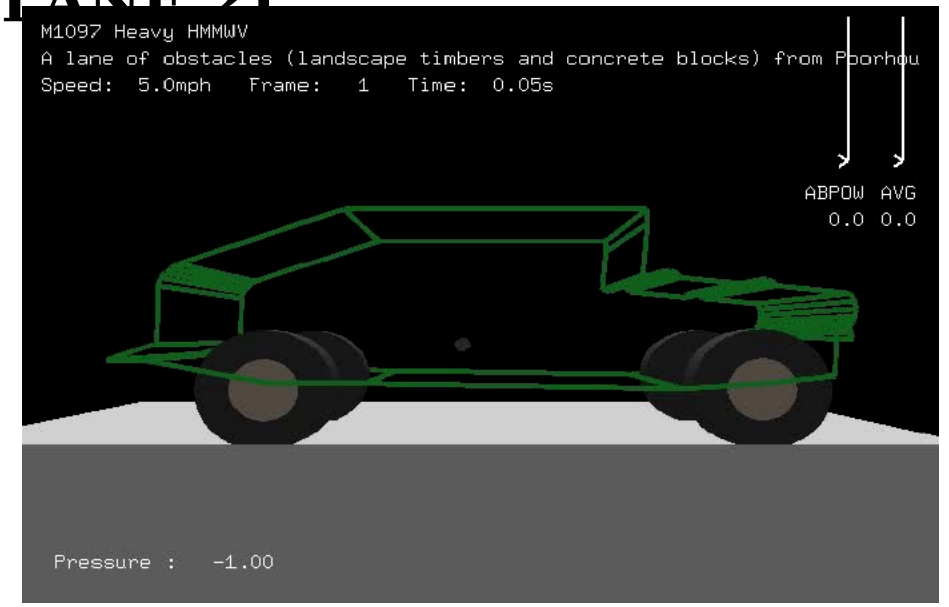


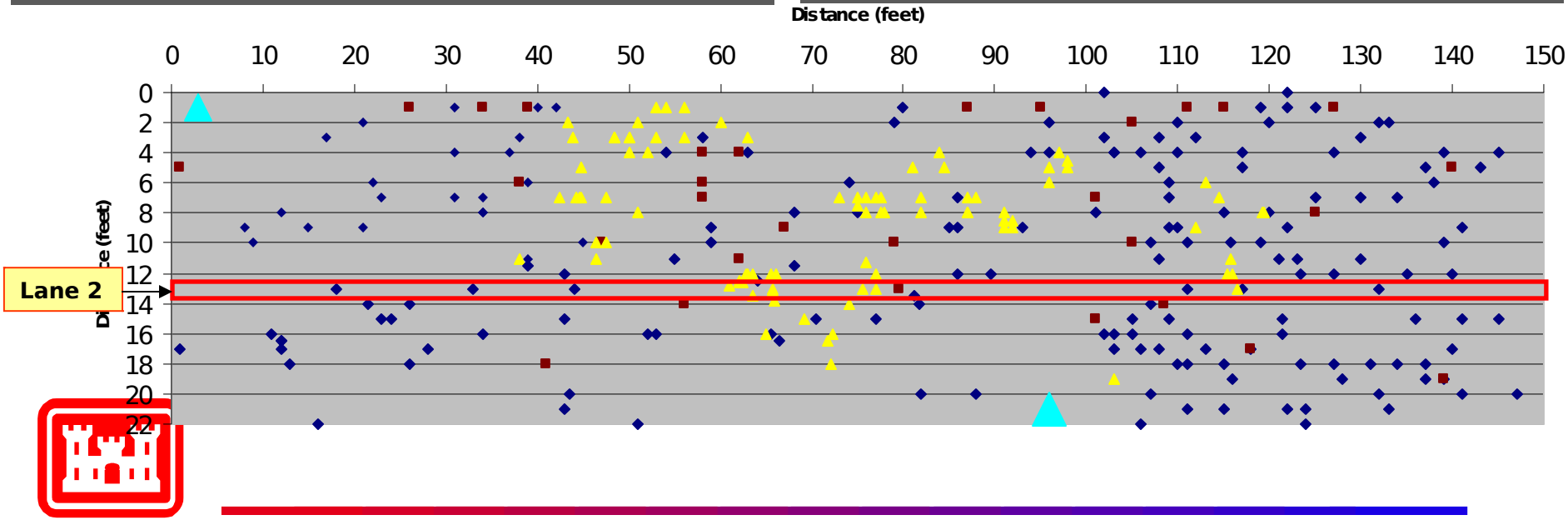
US Army Corps of Engineers

Engineer Research and Development Center

Vehicle Dynamics (VEHDYN III) Over Rubble and Debris (LANE 2)


M1097 Heavy HMMWV
A lane of obstacles (landscape timbers and concrete blocks) from Poorhou
Speed: 2.0mph Frame: 1 Time: 0.05s
ABPOW AVG
0.0 0.0
Pressure : -1.00

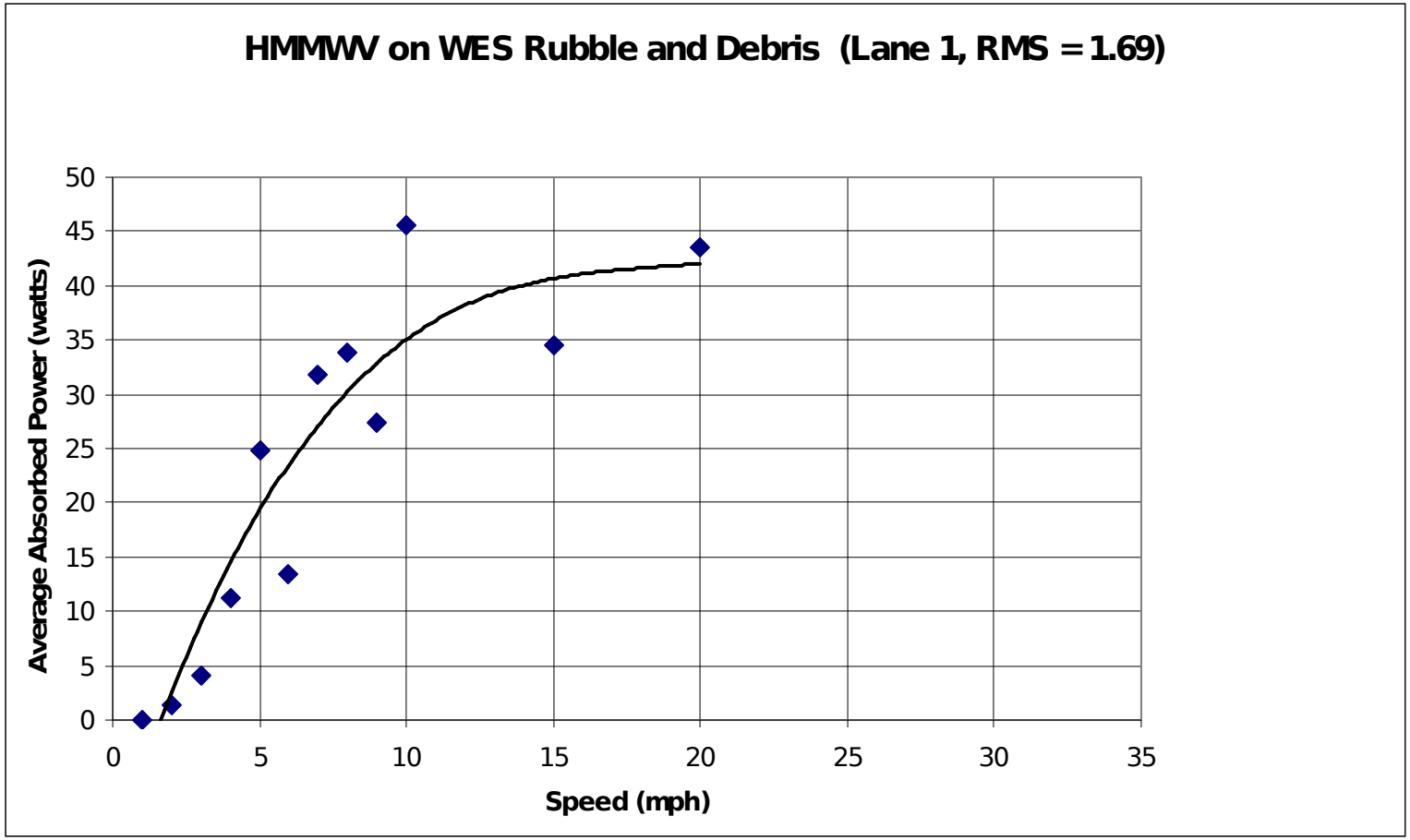

M1097 Heavy HMMWV
A lane of obstacles (landscape timbers and concrete blocks) from Poorhou
Speed: 5.0mph Frame: 1 Time: 0.05s
ABPOW AVG
0.0 0.0
Pressure : -1.00



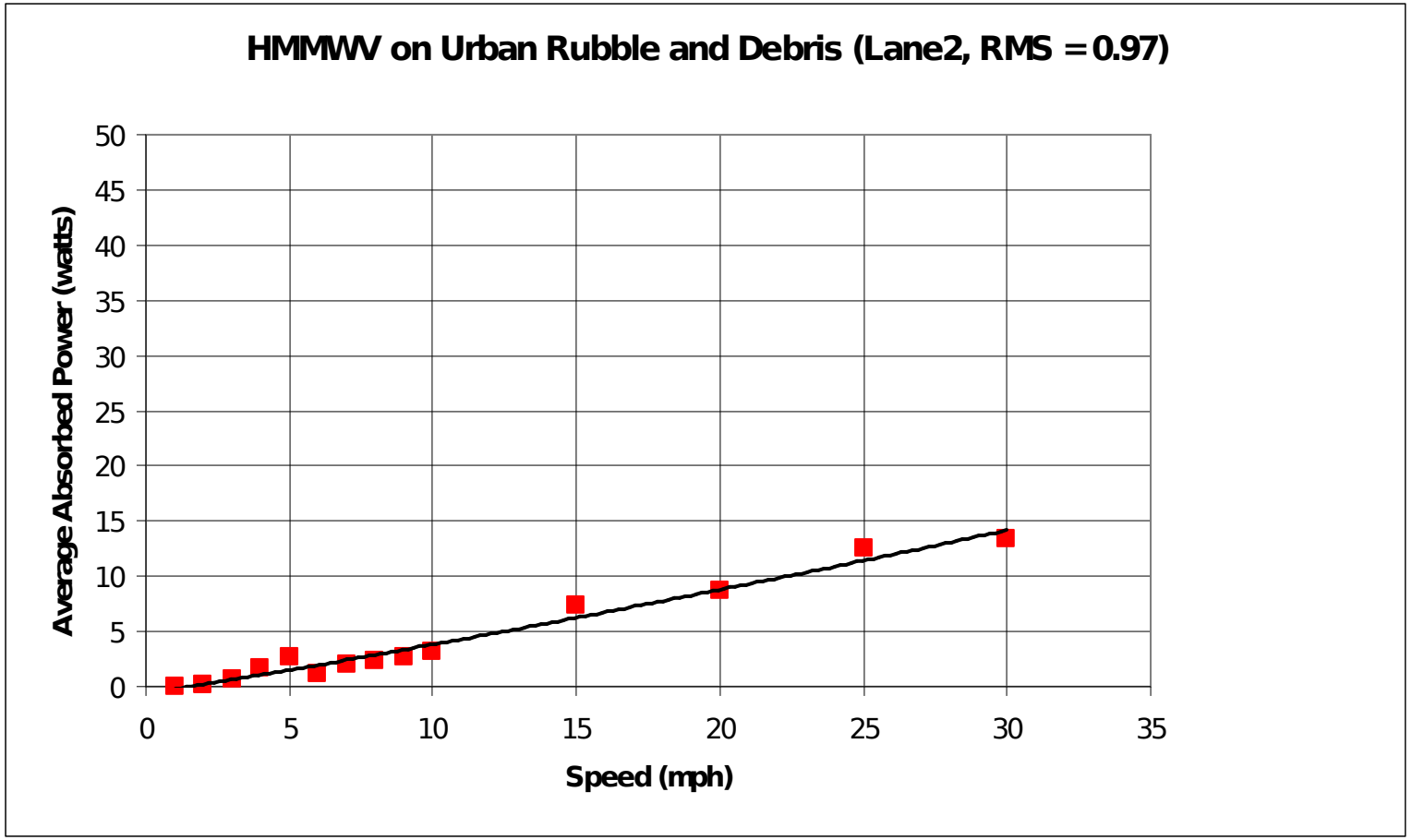
US Army Corps of Engineers

Engineer Research and Development Center

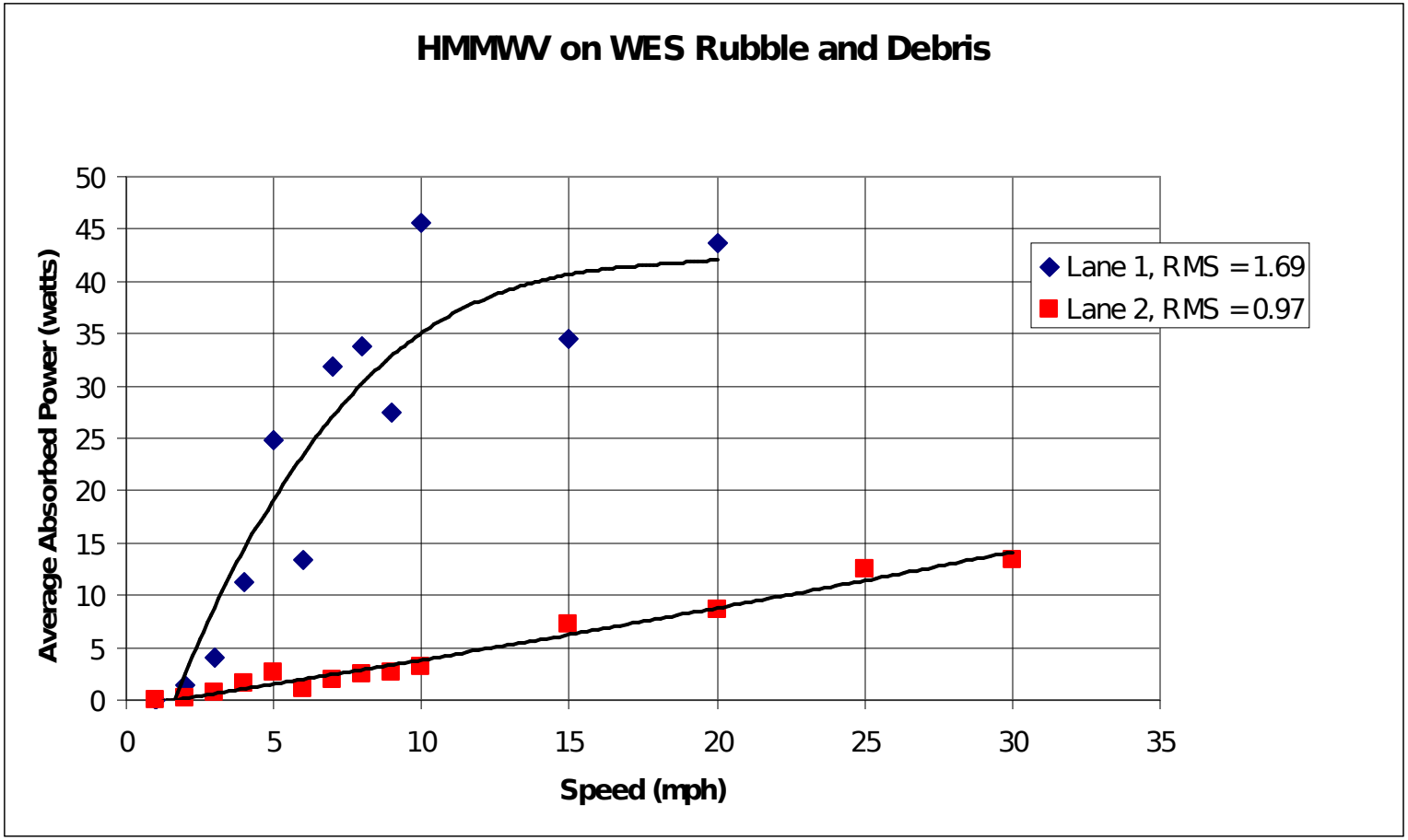
VEHDYN III Average Absorbed Power vs. Vehicle Speed



VEHDYN III Average Absorbed Power vs. Vehicle Speed



VEHDYN III Average Absorbed Power vs. Vehicle Speed

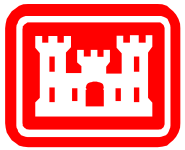


OOS EDM Terrain Feature Attributes Useful to Vehicle Mobility in MOUT

- **ROCK_DROP**
  - height
  - width
  - length
  - material type
- **RUBBLE**
  - height
  - width
  - length
  - surface slope
  - material type
  - stability
- **SIDEWALK**
  - terrain roughness (root mean square)
- **TERRAIN_CRATER**
  - depth
  - width
  - length
  - terrain roughness (root mean square)
- **TERRAIN_SURFACE**
  - terrain roughness (root mean square)

STNDMOB 3.0 Software Facts

- Written in JAVA
- Operates in Windows or Unix
- Uses XML for data file format and access
- Adheres to Software Engineering Standards
- Operates at about an order of magnitude faster than NRMM



Summary

- An implementation of a surface roughness/obstacle model for vehicle movement in MOUT for high resolution combat models is defined
- Preliminary results show that we are headed in the right direction
- Field tests are scheduled for May-June
- More model runs will be conducted